FINAL REPORT

MODELING ECONOMIC AND SOCIAL COSTS AND BENEFITS FOR WATER QUALITY CONDITIONS FOR NON-WOTUS AND OTHER STATE WATERS

Prepared for:

Arizona Department of Environmental Quality

P.O. # PO0000400338

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Introduction

ADEQ rulemaking requirements include establishing criteria for the economic, social and environmental costs and benefits for listing or delisting waters for protection in their program, and for setting standards for non-WOTUS and other waters of the state. Accordingly, this assignment is understood by the consulting team (Consultants) to focus on services pertaining to modeling the economic and social costs and benefits associated with decisions related to adoption of water quality standards[1] for non-WOTUS waters and other waters of the state, and for listing or delisting waters for protection within a new Surface Water Protection program.

In fulfillment of these purposes, the Consultants outlined a series of tasks applicable to both a Preliminary Deliverable package, which is this document, and final deliverables for subsequent completion. The outline of this work is shown in Appendix A.

To expedite the framework for the benefit/cost analysis with respect to this assignment, ADEQ identified three different classes of water bodies that could involve designation as non-WOTUS protected surface waters. ADEQ also identified specific water bodies to represent each class, as shown below:

Class 1 – Sky Island Stream. Representative Water – Stronghold Canyon, Cochise County

> Sky Islands are isolated mountain ranges in southeastern Arizona. These mountains contain a number of perennial or intermittent surface waters that have no significant nexus to a traditionally navigable water. The streams will die out in the deserts surrounding the sky island but are still important components of Arizona's overall hydrology.

Class 2 – Isolated Lakes. Representative Water – Pintail Lake, Show Low

> Allen Severson Memorial Wildlife Area/Pintail Lake is known in abbreviated form as "Pintail Lake." This wildlife area is actually a man-made wetland created from treated wastewater, and is recognized nationally as one of the first of its kind in the country.

Class 3 – Ecologically, Culturally, or Historically significant water. Representative Water – Quitobaquito Pond

> As a part of Organ Pipe Cactus National Monument, the National Park Service, in 1961, removed all old structures from the Quitobaquito Pond site, drained and deepened the pond, and constructed improvements to accommodate visitors and help protect the area.

These water bodies are described and discussed additionally in the material that follows.

[1] The Consultants' understanding with respect to "standards" is that standards can relate to a designation or other status of a water body but that current modeling efforts will not necessarily include quantified changes in standards for specific contaminants.

ADEQ requested, for purposes of this assignment, that the Consultants follow the benefit and cost estimating procedures outlined in a recent document prepared by EPA and the Department of the Army.[2] This approach required some interpretation by the Consultants.

First, the nationwide and state-by-state approaches that EPA takes with respect to their analyses in EPA (2021) must be understood in terms of how they relate to individual water bodies within any particular state. Costs are quantified at the state level for the 404 program, based on estimates of the number of permits that would be generated by changes in definition of waters, and then the direct costs (to permitees) of permits and related mitigation measures, and also additionally related administrative costs to the State (401). EPA provides information on costs related to 404 and 401 programs, and this information could be used within this benefit/cost analysis modeling framework under the assumption that the cost estimates on a per-unit (or per-permit) basis would be generally applicable to Arizona, even if the programs are not administered by the state.

These cost factors may not apply directly to the three case study examples. Since one of the sites is within a national monument, one is a relatively isolated mountain stream, and one relies on treated wastewater, activities requiring a Section 404 permit would be unlikely or very limited in these areas irrespective of changes in the definition of waters. Nevertheless, the concepts and approach described above should be applicable to Arizona waters generally.

Second, EPA (2021) provides an "annualized" cost (per-household and total) for each state based on an assumed number of permits/acres per year and using various factors, with costs projected over a 20-year analysis horizon. The 20-year cash outflow is then discounted to a present capitalized value and then converted to an annualized "payment." Benefits are treated similarly, and incorporate estimates such as the proportion of population within a "local" (as opposed to non-local) relationship to wetlands.

For the ADEQ case studies, it is recommended that EPA's cost annualizing methodology not be replicated. The reason for this recommendation is that the case studies will apply to discrete/individual projects (rather than a statewide assumption about generic multiple projects over 20 years). Since Section 404/401 costs for individual projects are assumed to be a one-time event, a straightforward cost per permit is recommended. Benefits pertinent to a particular water body, on the other hand, require an annualizing treatment similar to that applied by EPA to costs, because these are ongoing.

The Consultants also recommend a technical modification to the benefit modeling approach used in EPA (2021), which is to use a linear regression model instead of the nonlinear model used by EPA for their state-level estimates. The linear model affords a less complex process, which is also well suited to individual water bodies of relatively small size.[3]

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[2] *Economic Analysis For The Proposed Revised Definition of WOTUS Rule.* 2021. The study, referred to as "EPA (2021)" in this document, is a joint effort of the Environmental Protection Agency (EPA) and the Department of the Army.

[3] This recommendation is supported by Klaus Moeltner in conversations with him, and is also reflected in his paper used by EPA, Moeltner, et. al. (2019). Waters of the United States: Upgrading wetland valuation via benefit transfer. *Ecological Economics*, *164*, 106336.

Finally, for purposes of this assignment, certain waters of the state, including one of the case study examples, may not necessarily meet the official (federal or Arizona) definition of "wetland." Nevertheless, the value of a wetland to the public is assumed to be similar enough to the case study situations, and other potentially affected waters in Arizona, to allow the use of EPA's benefit modeling procedure (modified as noted herein) to derive Arizona estimates.

Limitations in benefit and cost definitions inherent in EPA (2021)

EPA acknowledges certain limitations in its relatively narrow approach to identifying benefits from protecting the quality of water. Moreover, a specific/individual water being evaluated may provide unique environmental and economic benefits beyond the EPA-calculated values for "typical" wetlands. Topics they mention as left unaddressed[4] include: the benefits of wetland carbon sequestration, the ability of wetlands to help allay the future effects of climate change, such as severe weather events, and the ability of wetlands to reduce soil erosion and retain flood waters (p. 86).

The EPA report focuses on assigning monetary values to benefits associated with wetland expansion/preservation, specifically through a meta-analysis of multiple wetland valuation studies that together provide insights into estimates of the public's willingness-to-pay (WTP) for wetland preservation. The nature of this type of analysis combines many different conditions and considerations, which tend to vary among the series of studies analyzed. The derived estimates can then be both generalized and also viewed in terms of the influence of the differing various conditions on monetary valuation. Using information from the EPA document, the source study that EPA relied heavily upon for this analysis, and supplementary data available through EPA, valuation differences attributable to varying conditions can be extracted, in order to structure models more closely tailored to specific localized conditions (for the waters, their uses, their surroundings, accessible populations, etc.). See also Tables 1 through 3.

Cost considerations mentioned in the EPA report *but not quantified* except for 401-related costs as they relate to the 404 program, are summarized in the following statement:

> "The definition of "waters of the United States" has a substantial effect on the implementation of other CWA programs, including the section 303(c) water quality standards program, the section 311 oil spill prevention program, the section 401 water quality certification program, and the section 402 NPDES permit program. A revised definition of "waters of the United States" would affect these CWA programs at both the federal and state level. Potential effects may vary based on a state's authority under their own state law to address aquatic resources and their capacity to address these aquatic resources through non-regulatory efforts" (EPA (2021) Executive Summary page xiv).

[4] In one discussion stating that they "omit known sources of benefits that are inherently difficult to quantify" (EPA 2021, p. xi).

In recognition of these limitations, particularly as they apply to benefit categories, the Consultants will further describe, in the final deliverable, potentially expanded modeling methods that may be appropriate for ADEQ benefit/cost analysis at some point in the future.

Preliminary analysis model structure

Figures 1 and 2 on the following pages, for the basic model structure and annotated version, respectively, summarize the framework of a benefit/cost analysis model that will be expanded upon as part of the final deliverable for this assignment.

Defining characteristics of the model

The model will ideally:

- Illustrate how multiple cases, conditions, etc. fit into a framework having multiple commonalities along with distinct components.
- Be designed to both summarize a process and link, conceptually and computationally, to the submodels that relate to the whole.
- Be user-friendly, "transportable," and adaptable.
- Encompass complexity and still remain comprehensible and media-manageable.

Physical structure and key components:

The final model will be based on an Excel workbook with multiple tabs, with submodels linking to the main table series. It will have a hierarchical framework: level 1 submodels are linked to relevant level 2 submodels, etc. and master data tables are feeding multiple submodels. Model overview diagrams in Figures 1 and 2 are intended to orient users to the model components, certain components of which are described below (letters and numbers match the diagram labeling).

A. Inputs, general:

- Standards by water type, if/as applicable to modeling, and relationships to uses, etc.
- Per-user (or per-something else) values tied to specific water use types, such as specific recreation activities, etc.
- Cost factors: permitting or other compliance (by some kind of unit), for public and private entities; user charges per unit by type; consideration of other factors such as health impacts (as burden), as applicable or practical at this level of analysis.
    - Directly quantifiable economic, indirectly quantifiable economic, social.
- Benefit categories:
    - Directly quantifiable economic, indirectly quantifiable, or identifiable only, economic, social.

B. Inputs, specific to a water body:

- Contaminants, standard, influence on uses, (as applicable)
- Human conditions: water supply, recreational potential, passive use/appreciation, property values

- Aquatic and wildlife conditions: variations by climate, effluent-dependent, ephemeral, etc.
- Affected populations by type of interaction.
- Cost factors: any variation from general factors based on specifics of water body; opportunity costs.
- Benefits: full scope and according to how topics fit into EPA-based model framework.

5. Costs tabulation: See Tables 4 through 6.

9. Sensitivity analysis component: Review of how the overall model structure relates to the specific analysis conditions in ways that could tend to over- or underestimate costs and/or benefits.

C. Affected entities:

- For benefits: geographic and demographic description of affected populations that are both "local" and "nonlocal" with respect to water body.
- For costs: types of entities affected, with costs allocated among them to extent possible.

FIGURE 1. BASIC MODEL STRUCTURE

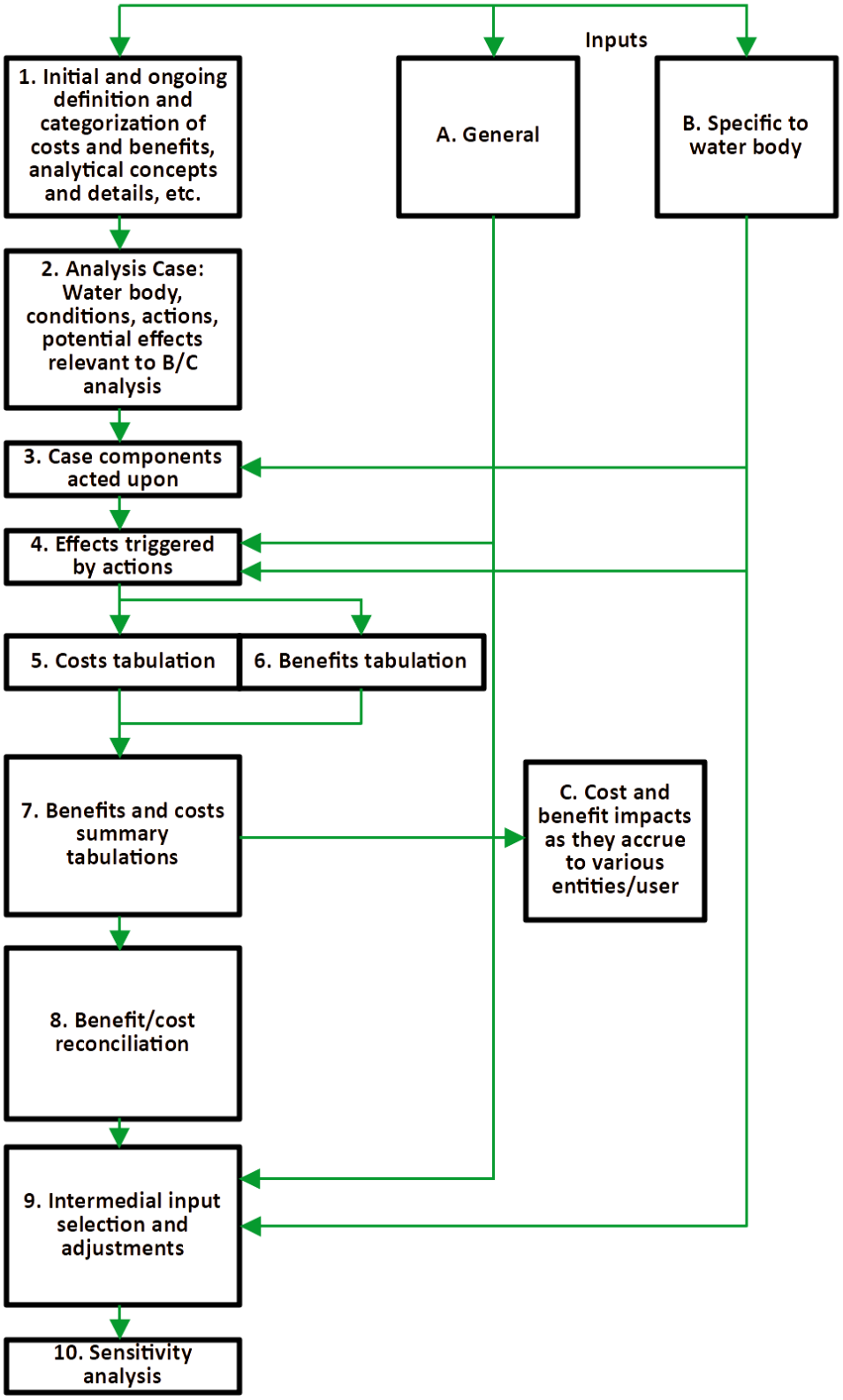
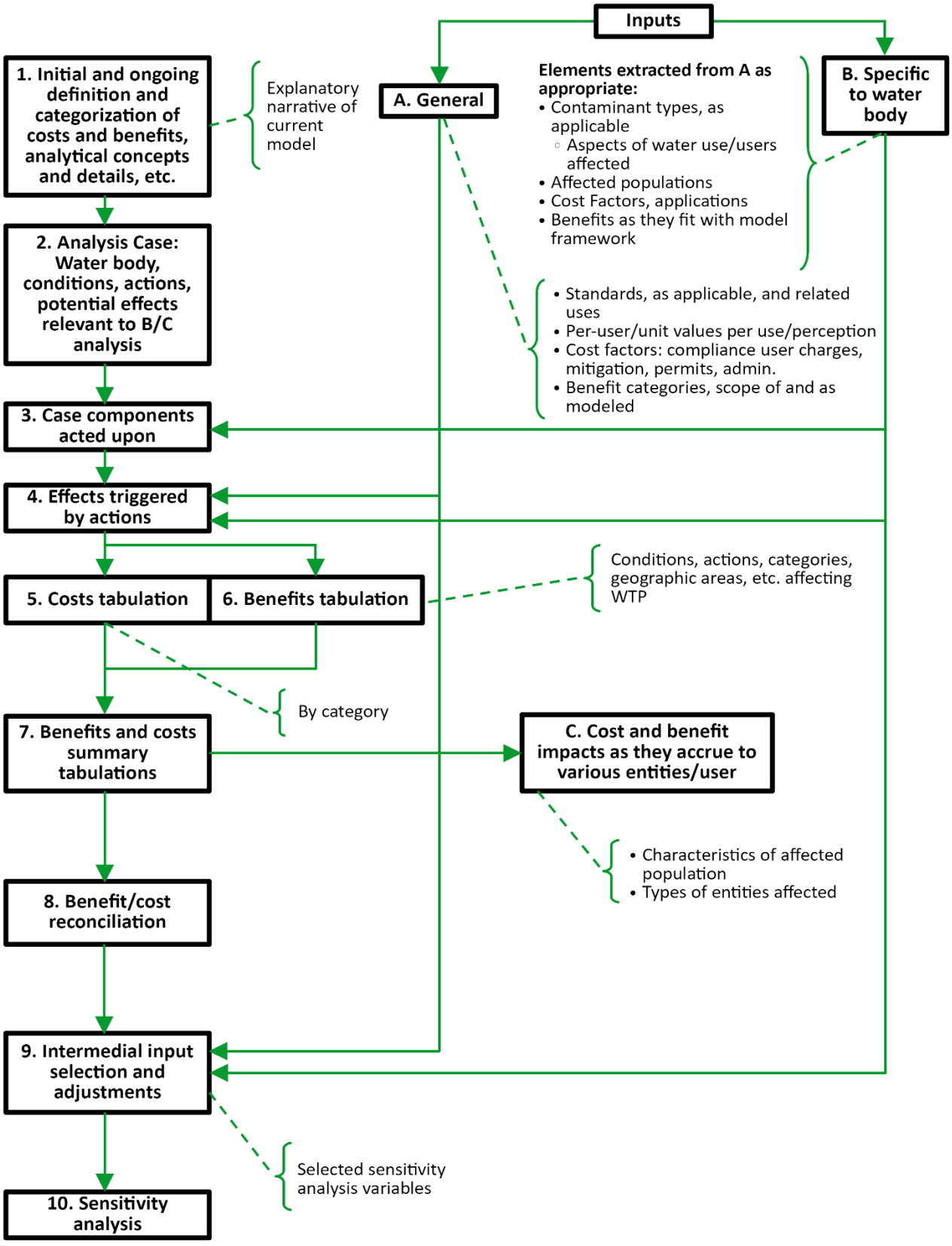


FIGURE 2. ANNOTATED MODEL STRUCTURE



Alignment of Arizona benefit and cost categories with EPA methods and documentation

Benefits pertaining to water class examples

Tables 1 through 3 show the following benefit conditions related to each of the three class type examples addressed in this assignment:

- Benefit categories / components
- Relevant quantities
- Proposed (final deliverable) approaches to benefit valuation
- Data resources / next steps (final deliverable)

Topics addressed within each of the three water class types will have broad applicability to other Arizona waters that would eventually be subject to analysis.

TABLE 1. CLASS 1 – SKY ISLAND STREAM. STRONGHOLD CANYON

Benefit Categories/Components	Relevant Quantities	Proposed (Phase 2) Approaches to Benefit Valuation	Data Resources/ Next Steps (Phase 2)
Wetlands, General Habitat Recreation • Hiking • Backpacking • Rock climbing • Equestrian • Birding Cultural significance (Cochise) Uniqueness of "sky islands" Within Coronado National Forest	*From existing project description:* • 4-mile hiking/equestrian trail • 0.12-mile interpretive trail *Additional information/ clarifications needed (Phase 2):* • Length or surface area of stream(s) • Habitat for any rare or endangered species? (At a minimum, Consultants will review the list of birds and document any especially significant species)	General wetlands value (EPA) applied to length or surface area of stream As a supplement to EPA's all-inclusive values for wetlands benefits, Consultants will quantify (where possible) and qualitatively document unique/special values for which this site is likely to exceed the lower-bound estimates captured within the EPA factors. For this site, these special values would include: • Birding/recreational values • Economic/employment benefits associate with outdoor recreation businesses	(Tentative) meta regression analysis of EPA-compiled willingness-to-pay (WTP) data; Consultants have preliminarily evaluated EPA database and will construct site-specific "predictive analysis" based on data variables relevant to this site.[5] Audubon study for birding/recreational values (county-specific and activity-specific data are available). If available, compile use/revenue data from: • Cochise Stronghold Campground (USFS) • Cochise Stronghold Retreat (Dharma Treasure Retreat) Qualitatively document business/economic benefits to outdoor recreation businesses listed in links section of Cochise Canyon website (and conduct supplemental online research to identify other affected businesses)

[5] As part of this evaluation, the Consultants conferred with the prime contributor to the EPA's benefit analysis based on the willingness-to-pay principle, Klaus Moeltner of Virginia Tech, who graciously provided additional data and direction regarding this effort.

TABLE 2. CLASS 2 – ISOLATED LAKES. PINTAIL LAKE

Benefit Categories/Components	Relevant Quantities	Proposed (Phase 2) Approaches to Benefit Valuation	Data Resources/ Next Steps (Phase 2)
Wetlands, General Habitat (birds) Habitat (big game) Recreation • Birding • Hunting • Hiking Within the larger Apache-Sitgreaves National Forests (with a full range of camping and other outdoor recreational activities)	*From existing project description:* • 50 acres of water within 250-acre fenced area • South Marsh fluctuates from 15-50 acres of flooded meadow *Additional information/ clarifications needed (Phase 2):* • Clarify acreages (is South Marsh part of total or separate?) • Habitat for any rare or endangered species? (At a minimum, Consultants will review the list of birds and document any especially significant species)	General wetlands value (EPA) applied to surface area of wetlands As a supplement to EPA's all-inclusive values for wetlands benefits, Consultants will quantify (where possible) and qualitatively document unique/special values for which this site is likely to exceed the lower-bound estimates captured within the EPA factors. For this site, these special values would include: • Birding/hunting/ • Recreational values • Economic/employment benefits associate with outdoor recreation businesses	(Tentative) meta regression analysis of EPA-compiled willingness-to-pay (WTP) data; Consultants have preliminarily evaluated EPA data base and will construct site-specific "predictive analysis" based on data variables relevant to this site. Audubon study for birding/ recreational values (county-specific and activity-specific data are available). Arizona Department of Fish and Game Study (2002): Economic Importance of Hunting and Fishing Online research to identify any local businesses directly/ indirectly supported by the visitors

TABLE 3. CLASS 3 – ECOLOGICALLY, CULTURALLY, OR HISTORICALLY SIGNIFICANT WATER. QUITOBAQUITO POND

Benefit Categories/Components	Relevant Quantities	Proposed (Phase 2) Approaches to Benefit Valuation	Data Resources/ Next Steps (Phase 2)
Habitat for (and only remaining U.S. populations of) rare and endangered species: • Sonoyta mud turtle (listed endangered species) • Quitobaquito pupfish (listed endangered species) • Quitobaquito spring snail (candidate threatened/ endangered species) • Desert caper plant • Caper butterfly Within the larger Organ Pipe Cactus National Monument (with a full range of camping and other outdoor recreational activities) Religiously significant springs	*From existing project description:* • Half-acre pond/reservoir (ADEQ RFP) • 12.3 acres of critical habitat for mud turtle (USFWS) • 0.8-acre pond with 0.34-acre wetland area (NPS) *Additional information/ clarifications needed (Phase 2):* • Reconcile acreage estimates (summarized above) from various sources • Determine if site is within International Biosphere Reserve	General wetlands value (EPA) applied to surface area of wetlands As a supplement to EPA's all-inclusive values for wetlands benefits, Consultants will quantify (where possible) and qualitatively document unique/special values for which this site is likely to exceed the lower-bound estimates captured within the EPA factors. For this site, these special values would include: • Rare/endangered species habitat • Cultural/religious values • (Indirect) recreational benefits associated with National Monument • (Indirect) economic/ employment benefits associate with outdoor recreation businesses	(Tentative) meta regression analysis of EPA-compiled willingness-to-pay (WTP) data; Consultants have preliminarily evaluated EPA data base and will construct site-specific "predictive analysis" based on data variables relevant to this site. FWS economic impact study related to the mud turtle; also review other endangered species valuation literature Audubon study for general (indirect) recreational values If applicable, incorporate valuation literature related to International Biosphere Reserve

Application of EPA's proposed refinement to estimating willingness-to-pay

In Appendix H of EPA (2021), the authors stated an intention, for the final rule analysis, to modify the methods for deriving two of the variables in the estimating equations related to WTP discussed elsewhere in this document: 1) affected number of households, and 2) household incomes for this affected group. In this modified method, a geographic information system (GIS) is used to select the areas in which households are assumed to have either a "local" or "nonlocal" (but still relevant) relationship to any given wetland or set of wetlands. This allows for more precise delineations of potentially affected households, including extension of any specific wetland/analysis area across state boundaries (where EPA had originally confined state-level estimates to state boundaries), and the potential for applying distinctions within affected populations for such things as the values they attach to wetlands (which to some extent can be generalized based on locational differences such as urban/rural, etc.).

This type of GIS-based approach works well with analyses of discrete to water bodies, and will be incorporated into the Consultant's recommendations for modeling as part of the final deliverable.

Cost estimation factors

Tables 4 through 6 show: 1) cost factors, 2) Arizona-specific or national quantified assumptions pertaining to these factors as reflected in EPA documents, and 3) notes on the application of figures to ADEQ benefit/cost modeling, related to the case studies and also general conditions for other waters.

TABLE 4. ESTIMATION FACTORS FOR SECTION 404 USACE PERMIT COSTS

Factor, per EPA	Arizona-specific Assumptions in EPA (2021)	Notes on Application
Average annual increase in Section 404 permits (individual permit, IP)	1.7	For case studies, ADEQ may provide estimated number of permits per year based on anticipated site-specific uses/activities
Average annual increase in Section 404 permits (general permit, GP)	117.0	
Cost per USACE permit in 2017 dollars, IP (low)[6]	$14,700	Adjust to current year dollars based on Consumer Price Index (CPI)
Cost per USACE permit in 2017 dollars, IP (midpoint)	$25,000	
Cost per USACE permit in 2017 dollars IP (high)	$35,300	
Cost per USACE permit in 2017 dollars, GP (low)	$4,400	
Cost per USACE permit in 2017 dollars, GP (midpoint)	$9,600	
Cost per USACE permit in 2017 dollars GP (high)	$14,700	

TABLE 5. ESTIMATION FACTORS FOR SECTION 404 MITIGATION COSTS

Factor, per EPA	Arizona-specific Assumptions in EPA (2021)	Notes on Application
Average annual increase in mitigation (acres)	13.4	For case studies, ADEQ may provide estimated mitigation requirements based on anticipated site-specific uses/activities
Average annual increase in mitigation (linear feet)	879	
Acreage – linear foot conversion factor	Assume 50' width/buffer (national data)	Need to discuss application with ADEQ staff (not clear how this factor is applied in EPA analysis)
Mitigation costs per acre in 2017 dollars (low)	$294	Adjust to current year dollars based on Construction Cost Index (CCI)
Mitigation costs per acre in 2017 dollars (high)	$675	
Mitigation costs per stream linear foot in 2017 dollars (low)	$54,000	
Mitigation costs per stream linear foot in 2017 dollars (high)	$84,000	

[6] For each permit type, the EPA (2021) document used the low end of the range of observed costs as the "low" estimate and the high end of the range as the "high" estimate. The cost numbers shown in the tables on this page are from a supplemental spreadsheet produced by EPA, outside the EPA (2021) document, creation date 9/29/2021 (file name: EPA-HQ-OW-2021-0602-0054_content). Note that GP high costs = IP low costs, per the data source, in Table 4.

Factor, per EPA	Arizona-specific Assumptions in EPA (2021)	Notes on Application
		As appropriate, override default AZ assumptions from EPA study (if ADEQ staff has customized data for specific sites/projects) Source of AZ data in EPA study is noted as Tim Wade, AZ GFD ILF Manager

TABLE 6. ESTIMATION FACTORS FOR STATE COSTS FOR SECTION 401 REVIEWS

Factor, per EPA	Arizona-specific[1] Assumptions in EPA (2021)	Notes on Application
Annual number of affected permits (individual)	10.30	For case studies, ADEQ may provide estimated number of affected permits per year based on anticipated site-specific uses/activities (for cost calculations, breakdown between individual and general permits is not needed)
Annual number of affected permits (general)	246.40	
Annual number of affected permits (total)	256.70	
FTE staff time per permit (low)	0.00069	Assumptions in EPA study are not state-specific but are based on available data from 11 states (not including Arizona) As appropriate, override default assumptions from EPA study based on ADEQ's forthcoming in-house cost analysis
FTE staff time per permit (mean)	0.00872	
FTE staff time per permit (high)	0.02138	
Average annual salary for state employee in 2017 dollars (U.S. average – not Arizona-specific)	$60,210	If using default salary assumption, adjust to current year dollars based on Gross Domestic Product (GDP) Deflator As appropriate, override default assumptions from EPA study based on ADEQ's forthcoming in-house cost analysis
Overhead factor used to adjust salary to total cost per employee	1.6	

1. Except as noted.

Literature review of Arizona-related documents potentially relevant to current or future benefit/cost modeling for Arizona waters

At ADEQ's direction, the Consultants reviewed a series of documents within ADEQ's developing on-line library. The annotated bibliography resulting from this analysis is attached as Appendix B.

Appendix A. Outline of Task Order Reports

		A	B
	Topic	**Preliminary Deliverables**	**Final Deliverables** (includes Preliminary Material plus any additions as noted)
1	**Applying EPA methods[7] for quantifying water-related costs and benefits to Arizona**		
1a	• General implications, limitations, and advantages of using	Narrative summary of issues	Narrative, including ADEQ commentary on preliminary material
1b	• Cost categories: types, nature of	Inventory and brief description	
1c	• Benefit categories: types, nature of	Inventory and brief description, also noting the crossover of benefits as costs foregone (and vice versa),	
1d	• Specific applications for quantifying Arizona conditions		Description of how the framework for applying EPA methods, etc. supports the specific language in ADEQ's rulemaking requirements
1di	○ Relationship of EPA categories to types of Arizona cost and benefit conditions: overlaps and distinctions	Matrix relating EPA categories, relatively general by nature, to Arizona categories that tend to be more specific and in some cases unique; and EPA's acknowledgment of topical and analytical limitations within their analysis framework	Description of how Arizona-specific categories of both costs and benefits, subsumed in EPA's methodologies, could, in future analyses frameworks, be identified, quantified, and otherwise treated to capture a more comprehensive range of costs and benefits and their interrelationships
1dii	○ Relationship of three case studies to general applicability within state	Matrix relating cost and benefit categories within the three case studies to EPA categories (as EPA generalizes them) and to the broader range of Arizona categories as outlined above	How the conditions in the three case studies relate to the descriptive framework discussed immediately above in 1di
2	**Benefit/cost modeling framework for Arizona**		
2a	• Model structure	Analysis flow diagram, main and sub-models (in overview and	(1) Model framework in XL workbook; (2) model with values applied and quantified results,

[7] *Economic Analysis For The Proposed Revised Definition of WOTUS Rule.* 2021.

		A	B
	Topic	**Preliminary Deliverables**	**Final Deliverables** (includes Preliminary Material plus any additions as noted)
		detailed versions), with narrative description	for each of the three case-study waters
2b	• Translation of EPA cost factors to Arizona	Description of how used in model	Application of numbers to 2a.B(2)
2c	• Translation of EPA benefit model framework to Arizona	Description of how used in model	Quantification of equations for application to 2a.B(2)
	• EPA's description of EPA's preference, in the future, for a GIS-based benefit transfer approach (as per Appendix H of their study)	Discussion of how this approach is readily adaptable to (and preferable for) current and any future analysis systems generated for Arizona	Application of concept into model (2a.B), and description of how it would be generally applied to Arizona cases, how fits with the advantages anticipated by EPA, etc.
3	**Other benefit/cost modeling in AZ**		
3a	• Annotated bibliography of pertinent documents	Annotated bibliography of selected reports/report types, highlighting aspects particularly relevant to this assignment	Annotated bibliography, additional relevant entries as identified
3b	• Types of benefits and costs addressed, and relevant levels of detail in treatment	Findings summarized	
3c	• Modeling methods from the literature potentially applicable to water-related analyses, present and future		Description of potential expanded modeling methods and how they could be applied to current conditions and to 1di.B

Appendix B. Annotated Bibliography

References

1. Arizona Administrative Register

Summary: The Administrative Register (Register) is a legal publication published by the Administrative Rules Division that contains information about rulemaking activity in the state of Arizona. The issues referenced below include code sections being amended and introduced to Chapter 11, which involves the Department of Environmental Quality Water Quality Standards.

Study Resource: These publications mainly refer to and make reference to topics that contribute to the Economic, Small Business, and Consumer Impact Statements. The studies referred to and referenced in this publication provide a brief summary of tourism, agriculture, or other benefits as well as cost categories or data produced from the findings. The following items are addressed in individual registers cited below:

Arizona Administrative Register (1995). Notice of Proposed Rulemaking, Title 18, Environmental Quality, Chapter 11, Department of Environmental Quality, Water Quality Standards, Volume 1, Issue 50.

Publication Study Resource: Proposed new section to the modification of water quality standards on the grounds of net ecological benefit based on the following criteria:

1. The discharge of effluent creates or supports an ecologically valuable aquatic; wetland, or riparian habitat in an area where such resources are limited
2. The cost of treatment to comply with a water quality standard is so high that it is more cost effective to eliminate the discharge of effluent rather than upgrade treatment
3. It is feasible for a point source discharger to completely eliminate the discharge of effluent
4. The environmental benefits associated with the discharge of effluent under a modified water quality standard exceed the environmental costs associated with elimination of the discharge and destruction of the effluent dependent ecosystem
5. All practicable point source control discharge programs, including local pretreatment, waste minimization, and source reduction programs are implemented
6. The discharge of effluent under a modified water quality standard will not cause or contribute to a violation of a water quality standard that has been established for a downstream surface water
7. The discharge of effluent will not produce or contribute to the concentration of a pollutant in the tissues of aquatic organisms or wildlife that is likely to be harmful to humans or wildlife through food chain concentration.

Arizona Administrative Register (1996). Notice of Final Rulemaking, Title 18, Environmental Quality, Chapter 11, Department of Environmental Quality, Water Quality Standards For Surface Waters – Economic Small Business and Consumer Impact Statement, Volume 2, Issue 20.

Publication Study Resource: The adopted Net Ecological Benefit rule provides a benefit to the owners of wastewater treatment plants that support or create effluent dependent waters because it provides a mechanism for relief from a water quality standard that otherwise might force costly treatment plant

upgrades. The adopted rule also provides ecosystem benefits in that it provides a regulatory incentive to maintain and preserve in-stream flows in areas where riparian and aquatic resources are limited. The continued discharge of effluent may provide net ecological benefits, even though an applicable water quality standard is not being met. Examples of possible ecological benefits include:

A. Enhancement, expansion or restoration of aquatic and riparian habitat for native, threatened or endangered aquatic species, or for migratory waterfowl
B. Provision or enhancement of habitat or food sources for native, threatened and endangered species that are terrestrial
C. Enhancement of species diversity
D. Enhancement or restoration of riparian values (e.g. cottonwood/willow habitat, improved bird and wildlife habitat)

Arizona Administrative Register (2001). Notice of Proposed Rulemaking, Title 18, Environmental Quality, Chapter 11, Department of Environmental Quality, Water Quality Standards, Volume 7, Issue 11.

Publication Study Resource: Proposed decision criteria for *Social and economic impact of Tier 3 antidegradation protection:* The Director may take into consideration the potential social and economic impact of a unique water classification and the establishment of Tier 3 antidegradation protection, including:

a. Impact of a prohibition of new point source discharges and expansion of existing point source discharges, including possible limits on discharges to the tributaries of a proposed unique water and possible impacts on growth and development.
b. Impact of possible future restrictions on land use activities in a unique waters watershed, including cattle grazing, timber harvesting, mining, recreation, and agriculture.
c. The impact of stricter requirements for §401 certification of federal permits and licenses, including NPDES and §404 permits.
d. Impact on private property rights and the potential for regulatory "takings."
e. Ecosystem and preservation values.

Arizona Administrative Register (2002). Notice of Final Rulemaking, Title 18, Environmental Quality, Chapter 11, Department of Environmental Quality, Water Quality Standards, Volume 8, Issue 13.

Arizona Administrative Register (2008). Notice of Final Rulemaking, Title 18, Environmental Quality, Chapter 11, Department of Environmental Quality, Water Quality Standards, Volume 14, Issue 52.

Arizona Administrative Register (2016). Agency Certificate Notice of Final Rulemaking, Title 18, Environmental Quality, Chapter 11, Department of Environmental Quality, Water Quality Standards, Volume 22, Issue 36.

Publication Study Resource: ADEQ proposed to eliminate the requirement that a discharger have a plan to eliminate the discharge under active consideration as part of what must be demonstrated. Communities and developers should benefit by eliminating an extra burden in seeking to use high quality effluent to create aquatic and riparian ecosystems.

Arizona Administrative Register (2017). Notice of Final Rulemaking, Title 18, Environmental Quality, Chapter 11, Department of Environmental Quality, Water Quality Standards, Volume 23, Issue 6.

Publication Study Resource: Estimated costs and benefits to consumers and the public mentioned in recreation activities (e.g., Ironman at Tempe Town Lake), fishing activities, and agricultural productivity.

Arizona Administrative Register (2019). Notice of Final Rulemaking, Title 18, Environmental Quality, Chapter 11, Department of Environmental Quality, Water Quality Standards, Volume 25, Issue 5.

Publication Study Resource: See notes regarding interface with AOT studies under *Agriculture in Arizona's Economy* and *The Economic Contributions of Water-related Outdoor Recreation in Arizona*, below.

2. Agriculture in Arizona's Economy

Summary: This report explores agriculture's contribution to the Arizona economy by examining the entire agribusiness system in Arizona.

Study Resource: The economic contribution analysis was conducted using input-output modeling and the premiere software for this type of analysis, IMPLAN Version 3.1. IMPLAN is a modeling system of a regional economy that is based on national averages of production conditions. This model was refined based on the best available data to more accurately reflect production conditions in Arizona.

Applicability to current benefit/cost estimating procedures: The IMPLAN system translates *direct* economic effects of some action into *secondary* effects, reflecting the multiplier effects of actions through the economic system. This common practice in economic impact assessments would be a logical eventual extension of cost and benefit estimating in relation to water body changes/designations.

Kerna, A., & Frisvold, G. (2014). Agriculture in Arizona's Economy: An Economic Contribution Analysis. *Department of Agricultural & Resource Economics. University of Arizona*.

3. Buehman Canyon Creek – Economic Benefits of Unique Water Designation Study of Buehman Canyon Creek

Summary: This study reviews the economic benefits of Buehman Canyon Creek for the consideration of determining the water body as a unique water designation.

Study Resource: The information summarized in this study provides guidance on what factors need to be considered in a comprehensive examination of probable costs and benefits in the economic impact statement on a proposed unique water designation.

Applicability to current benefit/cost estimating procedures: This study mentions economic benefits that are quantifiable, but does not include the data methodology used to support the economic benefits associated with the proposed unique water designation for Buehman Canyon Creek.

Colby, B.G. (1996) Buehman Canyon Creek – Economic Benefits of Unique Water Designation Study – March 1996. *Arizona Department of Environmental Quality*.

4. The Economic Benefits of Recreation in Rural Arizona

Summary: This report provides a summary analysis of tourism and recreation as factors influencing the state's economy and local economy's withing the state.

Study Resource: This report summarizes park recreation tourism economic benefits, the benefits to rural areas, and the need to develop more facilities to access recreation lands. Drawing from the published survey of visitors of Arizona State Parks conducted between 1987-1988, visitors were asked how much money their group spent during their trip within 50 miles of the state park they were visiting, average expenditures were produced per visitor group per trip and were applied to park attendance counts to document total expenditures spent within 50 miles of state parks by visitors in 1987.

Applicability to current benefit/cost estimating procedures: The reference cited for this source entitled "*The 1987-1988 Use Study of Arizona State Parks Visitors*" for the Arizona State Parks Board in 1989 provides some quantifiable data for visitor expenditures that lends itself to establishing captured economic benefits of this type.

Spear, S. (1989) Rural Arizona… The Economic Benefits of Recreation, A Summary Analysis of Tourism and Recreation as Factors Influencing State and Local Economies. *Arizona State Parks Board Statewide Planning Section.*

5. The Economic Contributions of Water-related Outdoor Recreation in Arizona

Summary: A study of outdoor recreational activity on or along the water to estimate the level of participation in the state and the contributions from these activities to the county and state economies.

Study Resource: The analysis is structured around estimating three sets of metrics: participation, spending, and economic contributions. Participation estimates for this study relied largely on two data sources to characterize outdoor recreation on or along the water. Economic Contributions were estimated by combining spending estimates with data that models economic sector interactions in a given geography. Expenditure data were collected for different categories (e.g., groceries, fuel, equipment, etc.) as part of the OIA survey, which enabled allocation of spending to specific economic sectors. These data were then run through an IMPLAN™ model of the Arizona statewide economy using software produced by MIG, Inc. The resulting county-level and water-specific estimates reflect the contribution that outdoor recreation in those locales has on the statewide economy. Appendix A in the document provides additional background information on economic contributions.

Applicability to current benefit/cost estimating procedures: See notes on IMPLAN under *Agriculture in Arizona's Economy*. The Arizona Office of Tourism (AOT) sponsors periodic generalized studies related to Arizona visitors, including types of activities, expenditures, economic impacts, etc. To the extent that benefit/cost modeling of water bodies/designations is expanded into specific consideration of benefits related to riparian-focused activities, these location/activity-specific studies (#4 as well as this one) can add to the specificity of benefits associated with activities of particular interest.

Southwick Associates (2019). The Economic Contributions of Water-related Outdoor Recreation in Arizona: A Technical Report on Study Scope, Methods, and Procedures. *Audubon Arizona*.

6. Socioeconomic consequences of mercury use and pollution

S*ummary:* In the past, human activities often resulted in mercury releases to the biosphere with little consideration of undesirable consequences for the health of humans and wildlife. This paper outlines the pathways through which humans and wildlife are exposed to mercury.

Study Resource: This paper examines the life cycle of mercury from a global perspective and then identifies several approaches to measuring the benefits of reducing mercury exposure, policy options for reducing Hg emissions, possible exposure reduction mechanisms, and issues associated with mercury risk assessment and communication for different populations. This study also briefly reviews the methods used to quantify the benefits to human health associated with reduced mercury exposure, which include Benefit-cost Analysis and the Cost-effectiveness Analysis.

Applicability to current benefit/cost estimating procedures: This paper does not include any quantifiable data used in its review of the Benefit-cost Analysis or Cost-effectiveness Analysis.

Swain, E. B., Jakus, P. M., Rice, G., Lupi, F., Maxson, P. A., Pacyna, J. M., ... & Veiga, M. M. (2007). Socioeconomic consequences of mercury use and pollution. *Ambio*, 45-61.

7. Nature-based Tourism and the Economy of Southeastern Arizona

Summary: This study documents expenditures in the Sierra Vista area by visitors to the San Pedro Riparian National Conservation Area (RNCA) and by bird watchers at Ramsey Canyon Preserve. Information on visitor expenditures, characteristics and preferences is reported, along with implications for nature-based tourism in southeastern Arizona. This study examined visitation to only two natural areas and so economic impacts reported here represent only a portion of the impacts of visitor spending associated with all nature preserves located in southeastern Arizona. The study indicates that 95% of visitors to Ramsey Canyon and the San Pedro RNCA go to at least one other site in southern Arizona on a typical visit to the area, and make expenditures in communities located near these sites.

Study Resource: The expenditure analysis indicates the importance of an overnight stay for communities to experience significant economic benefits from visitors.

Applicability to current benefit/cost estimating procedures: See notes regarding interface with AOT studies under *The Economic Contributions of Water-related Outdoor Recreation in Arizona*, above.

Crandall, K., Leones, J., & Colby, B. G. (1992). *Nature-based Tourism and the Economy of Southeastern Arizona: Economic Impacts of Visitation to Ramsey Canyon Preserve and the San Pedro Riparian National Conservation Area, Final Report*. Department of Agricultural and Resource Economics, the University of Arizona.